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Sufficiency of Assessment Models to Estimate Measures of Stock Status Relevant to Biological Reference Points

A Working Paper in Support of Term of Reference 6

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Introduction

The definition of Biological Reference Points (BRP) for fish stock is an essential component of stock assessment. Measures of abundance and harvest rates derived from assessment models are compared to standards that constitute desirable states for each stock. These states are designed to achieve maximum sustainable yield and may include some consideration of uncertainty in estimation. While the definition of BRPs is beyond the scope of this meeting, it is necessary to determine if the assessment models are sufficient for comparison with existing or future biological reference points. For stocks that are subject to mandatory rebuilding programs, the relationship between assessment model and reference points becomes more complicated. The assessment model must produce outputs that can be forecast under various harvest scenarios. Estimating the relative probability of achieving biological reference points under alternative strategies allows managers and economists to incorporate social and economic impacts into rebuilding plans. While the "checklist" comparison of model outputs to reference points is seemingly trivial, the details are often complicated.

This working paper summarizes the basic approaches for estimation of BRPs associated with the candidate models. It also highlights any special considerations associated with reference point estimation.

General Approaches

Biological reference points can be derived as part of the model identification and estimation process. For lack of a better term, these can be called internal estimates of BRPs as they rely on specification of stock recruitment relationship within the assessment model. The derived parameters can either be used to directly define reference points or, where analytical solutions are more complicated, to parameterize simulation or forecasting models to derive BRPs and measures of uncertainty. Internal estimates are advantageous since they incorporate the full uncertainty of the model estimation and potentially, covariances among parameters as part of the uncertainty in reference points. This can also be a disadvantage when the model does not fit particularly well. In these cases, the BRPs can be unstable, varying with minor changes in model configuration.

"External" estimators of BRPs use model outputs of abundance, SSB, recruits and fishing mortality as inputs to stand alone models. In the Northeast these include stock recruitment models (SRFIT), yield per recruit models (YPR), and stochastic population projection models (AGEPRO). The SRFIT program uses AIC methods to identify appropriate models from either Beverton-Holt or Ricker stock-recruitment models with and without correlated error terms. When an acceptable model can be defined, standard approaches can be used to estimate Fmsy and Bmsy values.

If none of the parametric models are acceptable, a nonparametric method is used to estimate proxy values for Fmsy and Bmsy. These proxies are derived by combining standard yield per recruit (YPR) and SSB per recruit (SSB/R) methods with model based estimates of absolute recruitment. Model parameters can be used to define appropriate partial recruitment vectors for YPR analyses leading to estimates of Fmax. Fmax serves as a proxy for Fmsy. SSB/R estimates for F=Fmax can be multiplied by some function of the recruitment time series to obtain an estimate of SSBmsy or Bmsy. The term “some function” can imply a simple mean of the recruitment series or other measure of central tendency. Under some circumstances, there may be justification to restrict the function of recruitment to a more recent stanza associated with something like changing environmental conditions. Another important consideration in the estimation of reference points is the selection of average weights at age. These have important consequences for the F associated with maximum yield and for biomass targets. Often the choice of the appropriate stanzas are influenced but not determined by the estimation model outputs. Consideration of ecosystem conditions, trends in other populations or evidence of environmental trends can be relevant.

Table 1 provides a simplified overview of the candidate models used for estimating stock status and their relationship to biological reference points. For each stock and associated model it will be helpful to summarize the expected set of models that will be used to estimate BRPs and any special conditions likely to apply.

Table 1. Summary of candidate estimation models and their relationship to Biological Reference Points.

Estimation Model	Reference Point Approach	Estimation of F Reference Point	Estimation of Biomass Reference Points	Forecasting Model	Special Considerations
AIM	Mixed. Reference point for harvest rate is estimated internally; BRP for biomass index must be externally defined.	AIM esimate a relative F associated population stability. Relative Fs greater than this BRP are likely to reduce population size and vice versa.	AIM does not estimate biomass reference points. Instead, these values, expressed as relative measures of abundance must be defined by externally (e.g., as a desired percentile of historical abundance index time series.	AIM has a simple linear population model that can be used to make stochastic projections of relative biomass and absolute catches. The projection module is included in the model.	AIM does not include multiple indices and therefore, reference points are based on a single survey. Assumption of linearity limits utility of longer term forecasts.
ASPIC	Internal. Bmsy and Fmsy are derived as part of the model fitting.	Fmsy and its variance can be estimated directly	Bmsy and its variance can be estimated directly	ASPIC has an internal forecasting model although it may not be able to handle mixed harvest policies (i.e., quota vs F strategies).	Estimates can be unstable when the model fits poorly. Estimates of F and B often represented as F/Fmsy and B/Bmsy ratios to reduce variance. Such estimates can be problematic if the denominator term is variable.
SCALE	External	Similar to ADAPT but requires Length-based YPR (also in NFT)	Similar to ADAPT but requires length based YPR (also in NFT)	Not available	SCALE model is promising because it allows for use of length based data.
VPA-ADAPT	External	ADAPT does not estimate biological reference points for F. However it does estimate age specific Fs and partial recruitment rates that can be used to parameterize yield per recruit models for estimation of Fmax, F0.1 and various F%MSP alternatives.	ADAPT does not estimate BRPs for Biomass. Estimates of SSB and Recruits can be used to externally define Stock-Recruitment relationships. The time series of recruitment estimates can be used in conjunction with SSB/R to predict SSB targets	VPA-ADAPT use bootstrap methods to generate a set of initial population vectors for the NFT AGEPRO module.	F estimates generally refer to F on the fully recruited age classes. Such estimates are comparable among models and with BRPs if and only if, the partial recruitment vector in the estimation model is equal to the PR vector in the YPR analyses. Otherwise, the force of mortality will be distributed differentially over age classes and predictions of yield and SSB will be incorrect.
STATCAM	External	Similar to ADAPT	Similar to ADAPT	To Check	
ASAP	Internal. Bmsy and Fmsy are derived as part of the model fitting.	Flexible	Flexible	ASAP uses MCMC methods to estimate a set of initial population vectors for the NFT AGEPRO module.	Condition similar to VPA-Adapt apply
SS2	Internal. Bmsy and Fmsy are derived as part of the model fitting.	Internal. Bmsy and Fmsy are derived as part of the model fitting.	Internal. Bmsy and Fmsy are derived as part of the model fitting.	Internal	Need to ensure model outputs are useful to management process in NEFMC Groundfish FMP.